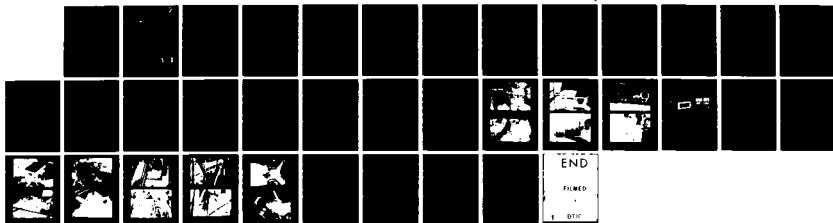


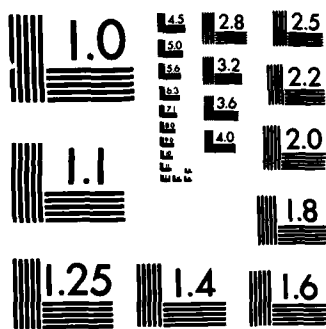
SAFETY AND HUMAN FACTORS ENGINEERING ANALYSIS - HEAT  
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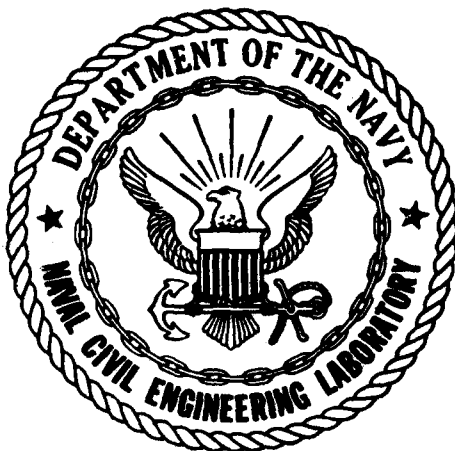
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**CR 82.033**

**NAVAL CIVIL ENGINEERING LABORATORY**  
Port Hueneme, California

Sponsored by  
**NAVAL FACILITIES ENGINEERING COMMAND**

**SAFETY AND HUMAN FACTORS ENGINEERING ANALYSIS – HEAT RECOVERY  
INCINERATOR INSTALLATION**

**September 1982**

**An Investigation Conducted by  
VSE CORPORATION  
3410 South A Street  
Oxnard, California**

**N00123-82-D-0149**

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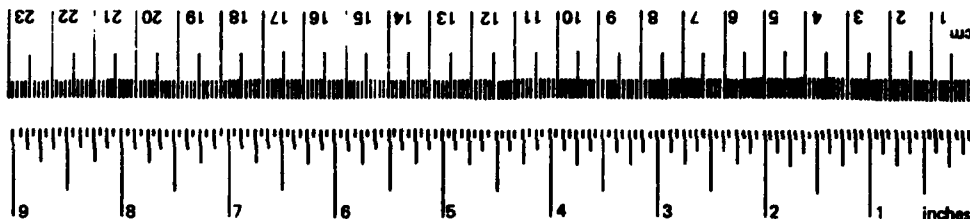
# METRIC CONVERSION FACTORS

## Approximate Conversions to Metric Measures

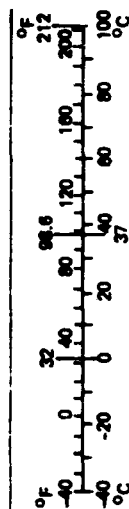
Symbol	When You Know	Multiply by	To Find	Symbol
in ft yd mi	inches	*2.5	centimeters	cm
	feet	30	centimeters	cm
	yards	0.9	meters	m
	miles	1.6	kilometers	km
in <sup>2</sup> ft <sup>2</sup> yd <sup>2</sup> mi <sup>2</sup>	square inches	6.5	square centimeters	cm <sup>2</sup>
	square feet	0.09	square meters	m <sup>2</sup>
	square yards	0.8	square meters	m <sup>2</sup>
	square miles	2.6	square kilometers	km <sup>2</sup>
	acres	0.4	hectares	ha
oz lb	ounces	28	grams	g
	pounds	0.45	kilograms	kg
	short tons (2,000 lb)	0.9	tonnes	t
tsp Tbsp fl oz c pt qt gal ft <sup>3</sup> yd <sup>3</sup>	teaspoons	5	milliliters	ml
	tablespoons	15	milliliters	ml
	fluid ounces	30	milliliters	ml
	cups	0.24	liters	l
	pints	0.47	liters	l
	quarts	0.95	liters	l
	gallons	3.8	liters	l
	cubic feet	0.03	cubic meters	m <sup>3</sup>
	cubic yards	0.76	cubic meters	m <sup>3</sup>
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

## Approximate Conversions from Metric Measures

When You Know	Multiply by	To Find	Symbol
millimeters centimeters meters kilometers	LENGTH		
	0.04	inches	in
	0.4	inches	in
	3.3	feet	ft
meters kilometers	1.1	yards	yd
	0.6	miles	mi
square centimeters square meters square kilometers hectares (10,000 m <sup>2</sup> )	AREA		
	0.16	square inches	in <sup>2</sup>
	1.2	square yards	yd <sup>2</sup>
	0.4	square miles	mi <sup>2</sup>
	2.5	acres	
grams kilograms tonnes (1,000 kg)	MASS (weight)		
	0.035	ounces	oz
	2.2	pounds	lb
	1.1	short tons	
milliliters liters liters liters cubic meters cubic meters	VOLUME		
	0.03	fluid ounces	fl oz
	2.1	pints	pt
	1.06	quarts	qt
	0.26	gallons	gal
	35	cubic feet	ft <sup>3</sup>
	1.3	cubic yards	yd <sup>3</sup>
°C	TEMPERATURE (exact)		
	9/5 (then add 32)	Fahrenheit temperature	°F



\*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price \$2.25, SD Catalog No. C13.10.286.



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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report contains a safety and human factors analysis of the Navy's heat recovery incinerator (HRI) systems. These requirements were based on current military standards and an evaluation of the HRI's at NAS, Jacksonville and NS, Mayport, FL. The data collected were used to develop preliminary design criteria for future HRIs. →		

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The safety analysis lists specific areas where problems can occur and what should be done to prevent injury to plant personnel. The human factors design criteria section lists steps that can be taken to improve personnel and plant operating efficiency. Finally, specific problems that are occurring at NAS, Jacksonville and NS, Mayport are given.



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## 1.0 INTRODUCTION

This document contains the results of the system safety and human factors engineering analyses performed on the two Heat Recovery Incinerator (HRI) installations located at Naval Station (NS) Mayport, Florida and Naval Air Station (NAS) Jacksonville, Florida. Using the guidance of MIL-STD-882 for safety and MIL-HDBK-1472 for human factors, safety and human factors design criteria were established and included along with the results of the safety and human factors evaluation of NS Mayport and NAS Jacksonville HRI installations. Naval Civil Engineering Laboratory (NCEL), Port Hueneme, CA has been conducting short- and long-term testing under the cognizance of Naval Facilities Engineering Command (NAVFACENGCOM) to collect HRI reliability and maintainability, thermal efficiency, cost effectiveness, and solid waste characteristics data and to evaluate safety and human factors engineering characteristics. The results of these safety and human factors engineering analyses will be combined as part of the overall HRI project planning.

## 2.0 PURPOSE AND APPROACH

The purpose of this effort is to address significant safety and human factors considerations applicable to small-scale waste processing and heat recovery installation. Specifically, this task seeks to ensure that:

- (1) Safety consistent with mission requirements is incorporated in Heat Recovery Incinerator (HRI) systems.
- (2) Hazards associated with HRI systems are identified and evaluated.
- (3) Historical safety data generated by similar systems are considered and used where appropriate.
- (4) Minimum risk is involved in accepting and using new designs and materials.
- (5) Retrofit actions required to improve safety are minimized.
- (6) Modifications do not degrade the inherent safety of the system.

MIL-STD-882 and MIL-STD-1472 provides the basis for the safety engineering and human factors engineering analyses performed. The design criteria from these standards that apply directly to an HRI installation were extracted, and expanded based upon the evaluation of the NS Mayport and NAS Jacksonville HRI installation. These design criteria should be expanded as more HRI installations are evaluated.

### 3.0 SCOPE

Development of the information contained in this report required a thorough understanding of HRI operations and familiarization with HRI equipment. This was accomplished through constant interface with NCEL project engineers, discussion with HRI personnel during a four-day site visit, and a thorough evaluation of both installations during the same four-day site visit.

#### 3.1 Reference Documents

The following documents were used in acquiring an operational knowledge of the HRI installation at NS Mayport and NAS Jacksonville:

- (1) Operation and Maintenance Manual, Refuse Incinerator, Mayport Naval Station.
- (2) Operations and Maintenance Manual for Heat Recovery Incinerator Facility, Building 952, NAS Jacksonville, Florida, Volumes I and II, April 1980.
- (3) Long-Term Evaluation, Heat Recovery Incinerator System, Mayport, VSE Corporation, Oxnard, California, April 1982.
- (4) Operating Case History of the NAS Jacksonville Heat Recovery Incinerator Facility, July 1979 through June 1981, Civil Engineering Laboratory, Port Hueneme, CA, July 1981.
- (5) Test and Evaluation of the Heat Recovery Incinerator Systems at Naval Station, Mayport, Florida, CR 81-012, Civil Engineering Laboratory, Port Hueneme, CA, May 1981.

The following documents were used to provide the methods used in the safety and human factors analyses:

- (1) MIL-STD-1472B, Human Engineering Design Criteria for Military Systems, Equipment, and Facilities.
- (2) MIL-STD-882, System Safety Program Requirements.
- (3) NAVMATINST 5100.6, Implementation of System Safety Program.
- (4) MIL-STD-454, Standard General Requirements for Electronic Equipment.
- (5) MIL-H-48655, Human Engineering Requirements for Military Systems, Equipment, and Facilities.
- (6) DOD 5000.36, System Safety Engineering and Management.
- (7) OPNAVINST 5100.24, Navy System Safety Engineering and Management.

#### 4.0 TECHNICAL APPROACH

The safety and human factors engineering analyses included establishing engineering design principles from the standards listed previously. The results of the cursory safety and human factors engineering evaluation on the two HRI installations were then used to translate these principles into engineering design criteria. These design criteria can be used for all future procurements, but should be expanded as more installations are visited and additional engineering and testing data is collected.

#### 5.0 SAFETY ENGINEERING ANALYSIS

Previously referenced instructions emphasize the need for system safety management and engineering to be conducted throughout all phases of a system (i.e., HRI installation) life cycle.

The purpose of the system safety engineering analysis is to identify potential hazards and to insure adequate measures are taken to eliminate or control the hazard. The following three basic definitions are provided to help provide a better understanding of system safety.

- (1) Hazard. An existing or potential condition that can result in a mishap.
- (2) Mishap. An unplanned event or series of events that result in death, injury, occupational illness, or damage to or loss of equipment.
- (3) System Safety. Special application of system safety management and engineering principles whereby hazards are identified and risk minimized throughout all phases of the system life cycle.

MIL-STD-882 defines the system safety principles that apply to all systems, equipment, and facilities. Those principles that apply directly to HRI installations are summarized in the following:

- (1) Potential hazardous material (i.e., hydraulic fluid, solvents, lubricants, or fuels) shall be selected to provide optimum safety characteristics.
- (2) Isolate hazardous substances from activity areas, personnel, and incompatible materials.
- (3) Locate equipment so that access during operations, maintenance, repair, or adjustment minimizes personnel exposure to hazards, hazardous chemicals, high voltage, cutting edges, sharp points, and electromagnetic radiation.
- (4) Minimize hazards resulting from excessive environmental conditions (e.g., temperature, noise, toxicity, and vibration).
- (5) Design to minimize human error in the operation and support of the system.
- (6) Consider alternate approaches to minimize hazards that cannot be eliminated. Such approaches include interlocks, redundancy, failsafe design, system protection, fire suppression, and protective clothing, equipment, or devices.

During the site visit to the HRI installations at NAS Jacksonville and NS Mayport, these system safety engineering principles were used during the evaluation. The results of the evaluation of both HRI installations are contained in appendix A. Since both of these installations are experimental in nature, the result of the evaluation will be used only to help in establishing HRI system safety design criteria. This design criteria can be used for any future HRI procurements and to evaluate other HRI installations.

The following system safety engineering design criteria apply to any HRI installation. These safety engineering design criteria are organized by equipment and physical layout of an HRI installation.

#### SYSTEM SAFETY DESIGN CRITERIA - HRI

(1) Tipping floor and pit area.

- (a) Delivery of solid waste shall not require backing to the tipping floor.
- (b) Waste material must be isolated from all operating equipment.
- (c) Personnel must wear protective clothing and equipment whenever in the tipping floor area.
- (d) Open pits must have protective stops to prevent loader from falling into pit.
- (e) Front-end loader requires special ties for gripping tipping floor surface.
- (f) Solid waste feed to the pit will not be performed manually.

(2) Equipment.

- (a) Moving components (i.e., conveyors, motor shafts/fans, fan belts, chain drives, etc.) will be enclosed.
- (b) Electrical equipment in a high dust environment should be encased to avoid shorting.
- (c) Voltages of 110 V or greater shall be clearly marked and covered.
- (d) Electrical equipment located in an outside environment will be covered.
- (e) ON/OFF controls must be located adjacent to the equipment. For equipment with remote control, local control must also be provided. Local control, when used, will prohibit remote commands.
- (f) Cutting edges, sharp corners, and points will be eliminated. Corners will be curved, not square.

(3) System.

- (a) All pipes carrying steam will be covered with insulation, be clearly marked, and show direction of flow.

- (b) Gas, waste oil, and fuel oil lines will be color coded.
- (c) Blowdown valves on boilers will be covered with insulation.
- (d) All subsystems under pressure will have relief valves.

(4) System Controls. The following indicators will be provided, as a minimum, to a centrally located, manned control station. All local indicators shall be at eye level:

- (a) Furnace pressure.
- (b) Gas pressure to boiler.
- (c) Gas pressure leaving boiler.
- (d) Gas pressure leaving dust collector.
- (e) Various incinerator air pressures (includes combustion and over-fire).
- (f) Boiler temperature, pressure, and water level.
- (g) Feedwater pressure.
- (h) Hydraulic pressure - low/high for ram feed
- (i) Deaerator tank - water level.
- (j) Jammed ram feeder.
- (k) Primary and secondary burner flame.

(5) Catwalks, Steps, and Ladders.

- (a) Catwalks will have toeboards and handrails.
- (b) Catwalks and steps shall have sufficient width for the operation planned.
- (c) Ladders will be a permanent part of the installation. Portable ladders will not be used.
- (d) Steps will be inclined to known standards and have handrails.

## 6.0 HUMAN FACTORS ENGINEERING ANALYSIS

This section presents general human factors/engineering design criteria applicable to the design and development of small-scale HRI facilities using

the guidance of MIL-STD-1472B. The criteria and principles contained herein are provided to:

- (1) Achieve required performance by operator, control, and maintenance personnel.
- (2) Minimize skill and personnel requirements and training time.
- (3) Achieve required reliability of interfaces.
- (4) Foster design standardization within and among systems.

To enhance the overall system effectiveness the HRI design must also consider other factors which degrade human performance or increase error probabilities. Such factors include personnel safety and health (addressed in section 4), discomfort and distraction, and system maintainability, design. For specific guidance in designing for maintainability, the reader is referred to MIL-HDBK-472.

#### 6.1 General Criteria

MIL-STD-1472B, defines the human engineering principles that apply to all systems, equipment, and facilities. Those principles that apply directly to HRI installations are summarized in the following. The design of HRI facilities should include consideration of factors that influence human performance including:

- (1) Satisfactory atmospheric conditions including composition, pressure, temperature, and humidity (and safeguards against uncontrolled variability beyond acceptable limits).
- (2) Range of acoustic noise, vibration, shock, and impact forces (and safeguards against uncontrolled variability beyond safe limits).
- (3) Protection from thermal, toxicological, electromagnetic, pyrotechnic, visual, and other hazards.
- (4) Adequate space for man, his equipment, and free volume for the movements he is required to perform during operation and maintenance tasks under both normal and emergency conditions.

- (5) Adequate physical, visual, auditory, and other communication links between personnel and between personnel and their equipment under normal and emergency conditions.
- (6) Efficient arrangement of operation and maintenance workplaces, equipment, controls, and displays.
- (7) Adequate natural or artificial illumination for the performance of operation, control, training, and maintenance.
- (8) Safe and adequate passageways, ladders, stairways, platforms, inclines, catwalks, and other provisions for ingress, egress, and passage under normal and emergency conditions.
- (9) Provisions for minimizing psychophysiological stress and fatigue.
- (10) Design features to assure rapidity, safety, ease, and economy of maintenance in normal, adverse, and emergency maintenance environments.
- (11) Satisfactory remote handling provisions and tools.
- (12) Clothing and personal equipment (C/PE) should be considered in the design, location, and layout of workspaces and maintenance access. Restrictions imposed on human performance by C/PE must be considered in task allocation.
- (13) Information processing rates, decision-making effectiveness, etc.

In addition, all controls, displays, marking, coding, labeling, and arrangement schemes (equipment and panel layout) should be uniform for common functions of all equipment. Criterion for selecting off-the-shelf commercial or Government equipment shall be to the degree to which the equipment conforms to this standard. Where off-the-shelf equipment requires modification to interface with other HRI equipment, the modification shall be designed to comply with the criteria contained in this document.

To assure that the equipment is capable of operation, maintenance, and repair by personnel with minimum training, the HRI equipment should represent the simplest design consistent with functional requirements.

Fail-safe design is one in which a failure or undesirable behavior will not adversely affect the safe operation of the system or equipment. A fail-safe design should be provided for those HRI areas where failure or unintentional behavior can disable the system or cause catastrophic results through equipment damage, personnel injury, or inadvertent operation of critical equipment.

#### 6.2 Specific Design Criteria

Specific human engineering design criteria relevant to HRI operations were extracted from MIL-HDBK-1472B. These criteria are directly applicable to the control (and control panel) processes at both NS Mayport and NAS Jacksonville installations.

- (1) Compatibility. Controls shall be compatible with their associated displays. Control-display relationships shall be functionally effective and require minimum interpolation on the part of the operator.
- (2) Relationship. The relationships of a control to its associated display and the display to the control shall be immediately apparent to the operator and free of ambiguities. Controls will normally be located adjacent to (preferably under or to the right of) their associated displays.
- (3) Functional Grouping. Functionally related controls shall be located in proximity to one another, arranged in functional groups (e.g., power, status, test).
- (4) Consistency. Location of recurring functional groups and individual items shall be similar from panel to panel.
- (5) Sequential Operation. Where sequential operations follow a fixed pattern, controls shall be arranged to facilitate operation (e.g., in a pattern left-to-right and top-to-bottom).
- (6) Remote Controls. Where controls are operated at a position remote from the display, equipment, or controlled vehicle control arrangement shall be established to facilitate direction-of-movement consistency.
- (7) Maintenance and Adjustment. In general, controls used solely for maintenance and adjustment and referred to infrequently shall be covered during normal equipment operation, but shall be readily accessible and visible to the maintenance technician when required.

- (8) Valve Controls. Rotary valve controls should open the valve with a counterclockwise motion. Valve controls shall be provided with double-ended arrows showing the direction of operations and appropriately labeled at each end to indicate the functional result (e.g., open and close).
- (9) Shape Coding (Controls). Control shapes shall be both visually and tactually identifiable and shall be designed to be free of sharp edges.
- (10) Color Coding. Controls shall be black or gray. Exceptions shall be in accordance with FED-STD-595.
- (11) Standardization. Coding of all controls within the system shall be uniform.
- (12) Lamp Testing. When indicator lights using incandescent bulbs are installed on a control panel, a master light test control shall be incorporated. When applicable, design shall allow for testing of all control panels at one time.
- (13) Color Coding (lights). Transilluminated light emitting diode (LED) and incandescent displays shall conform to the following color coding scheme:
  - (a) RED shall be used to alert an operator that the system or portion of the system is inoperative; or that successful mission is not possible until appropriate corrective action is taken.
  - (b) FLASHING RED shall be used only to denote emergency conditions which require operator action to be taken without undue delay, to avert impending injury.
  - (c) YELLOW shall be used to advise an operator that a condition exists which is marginal. YELLOW shall also be used to alert the operator to situations where caution is necessary.
  - (d) GREEN shall be used to indicate monitored equipment is in tolerance or that a condition is satisfactory to proceed.
  - (e) BLUE may be used for an advisory light, but preferential use of blue should be avoided.
- (14) Flashing Lights. The use of flashing lights shall be minimized. They should be used only when it is necessary to call the operator's attention to some condition requiring action.
- (15) Pushbuttons. Pushbuttons should be used when a control or an array of controls is needed for momentary contact or for activating a locking circuit, particularly in high-use frequency situations.

- (16) Levers. Levers may be used when a large amount of force or displacements is involved or when multidimensional movements of controls are required.
- (17) Labeling. Controls, displays, and other items that must be located, identified, read, or manipulated shall be clearly labeled to permit rapid and accurate human performance. Labels shall be placed on or very near the items which they identify but shall not obscure any information needed by the operator. They shall be placed in a consistent location throughout the equipment and system. Trade names and other irrelevant information shall not appear on labels or placards.
- (18) Auditory Displays. Auditory displays should be provided when it is desired to warn, alert, or cue the operator to subsequent additional response or when voice communication is necessary.

APPENDIX A

SAFETY AND HUMAN FACTORS OBSERVATIONS

This appendix contains a synopsis of safety and human factors concerns observed during site visits to NS Mayport and NAS Jacksonville HRI facilities. Figures A-1 through A-7 apply to NS Mayport and immediately follow the observations cited for this facility. Figure A-8 through A-17 follow the NAS Jacksonville observations.

#### NS MAYPORT

##### 1. Tipping Floor Area

- Solid waste trucks required to back into facility (see Figure A-1) creates "blindspot" hazards.
- Front-end loader tires not designed for cement tipping floor (see Figure A-2).
- No provisions to prevent loader from inadvertently driving into pit (see Figure A-2).
- Handsorting operations performed in close proximity to loader operations.
- Insufficient personal protective clothing. No hardhats or masks worn, few gloves.
- Handsorting requires frequent contact with toxics, glass, sharp and heavy objects.
- Efficiency of handsorting (especially visual inspection) suffers as waste pile up (height) increases. Can't see bottom materials. Also, some waste materials arrive in colored bags. Efficient sorting requires considerable manpower.
- Laborers subjected to odious solid waste fumes. Odor problems increase as moist waste remains in storage pit for long periods.

##### 2. Boiler and Incinerator Equipment

- Steam piping lines across floor in walkways (see Figure A-3).
- Drive shaft and sprockets on ash conveyor uncovered.
- Steam lines unmarked. Needs color coding and direction of flow marking.
- No metering-and-control board is provided near boiler for local control.

- Overhead crane controls (see Figure A-4) should be hard-wired to crane.
- Hot steam piping not easily identified by personnel.
- Drive shaft chain and sprockets not covered (see Figure A-5).
- Blowdown control lever located too low for a standing operator (see Figure A-6).

### 3. General

- Some labels on control panel obstructed from normal line-of-sight view (see Figure A-7).
- Manual control console is designed for seated operator while only intermittent interface is required.
- Dampened, aged waste causes somewhat intolerable malodor conditions within plant.
- Lack of conscientious safety and health program.

The following photographs (Figures A-1 through A-7) were taken at the NS Mayport installation.

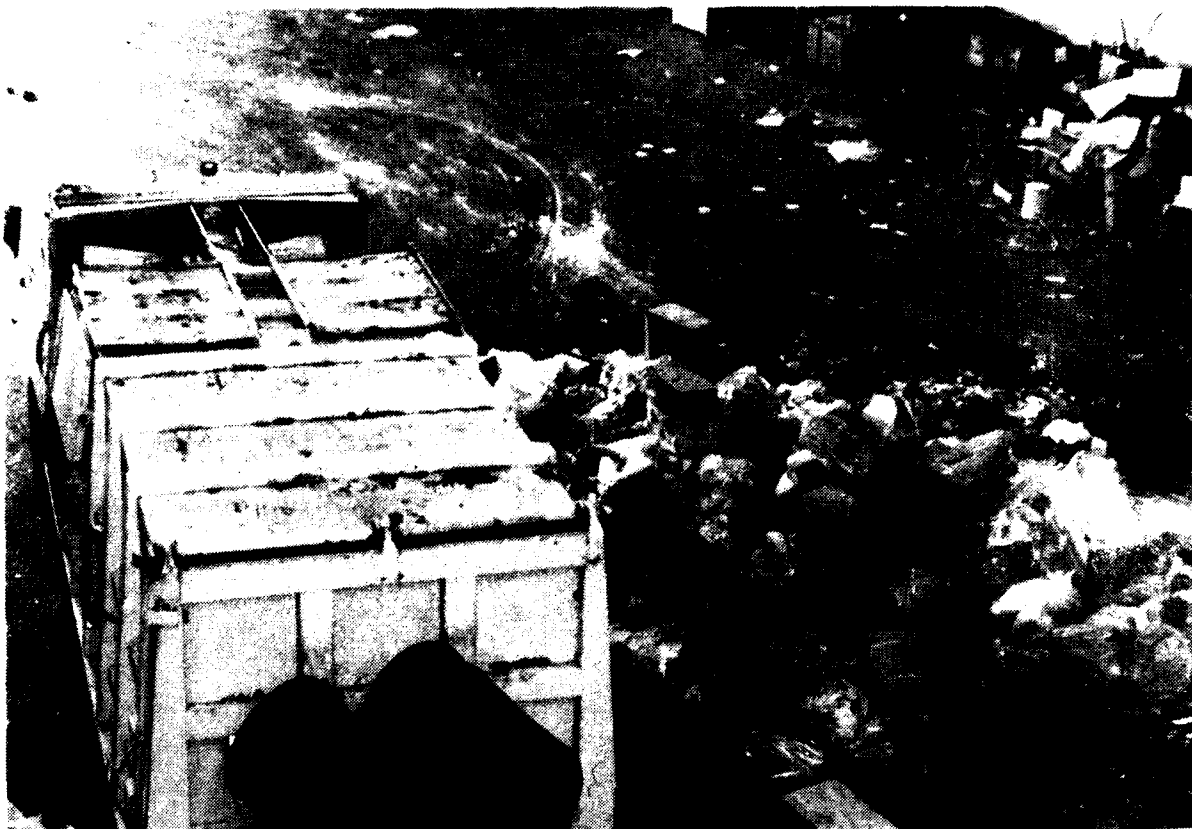


Figure A-1. Tipping floor.

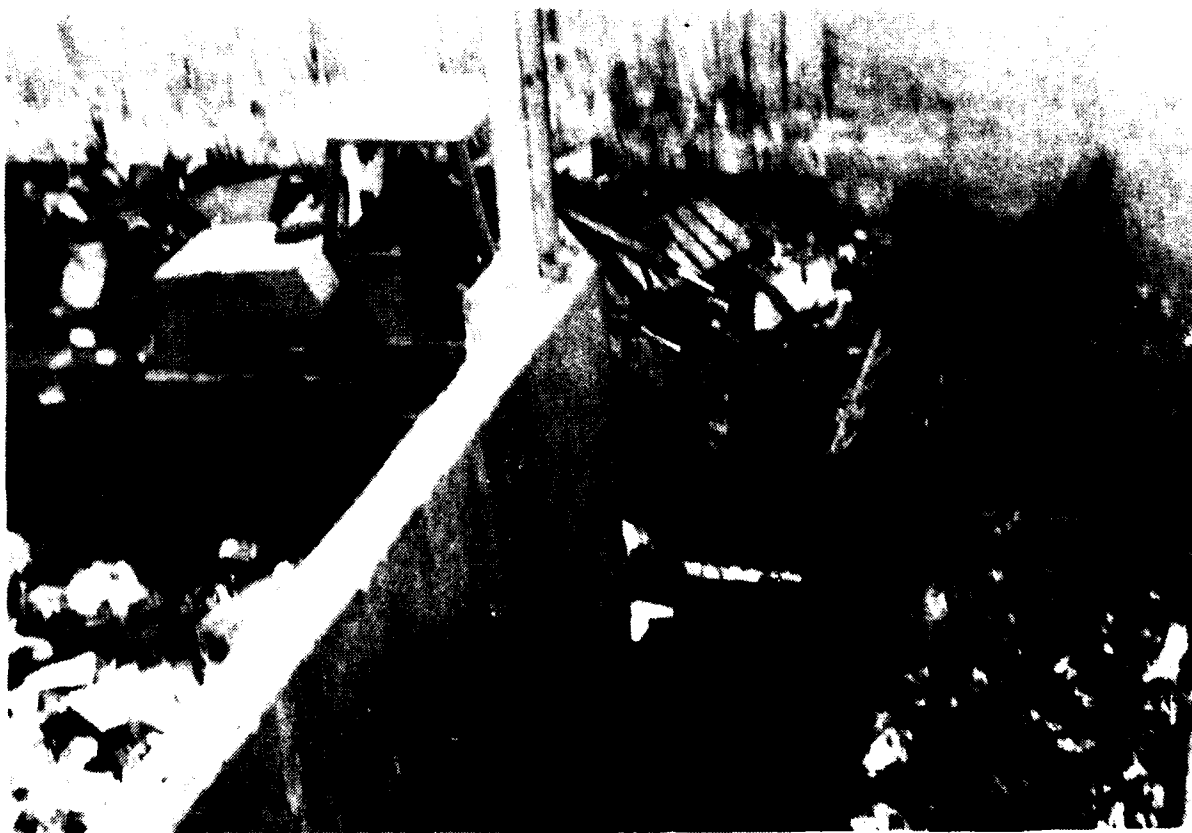


Figure A-2. Front-end loader operations.

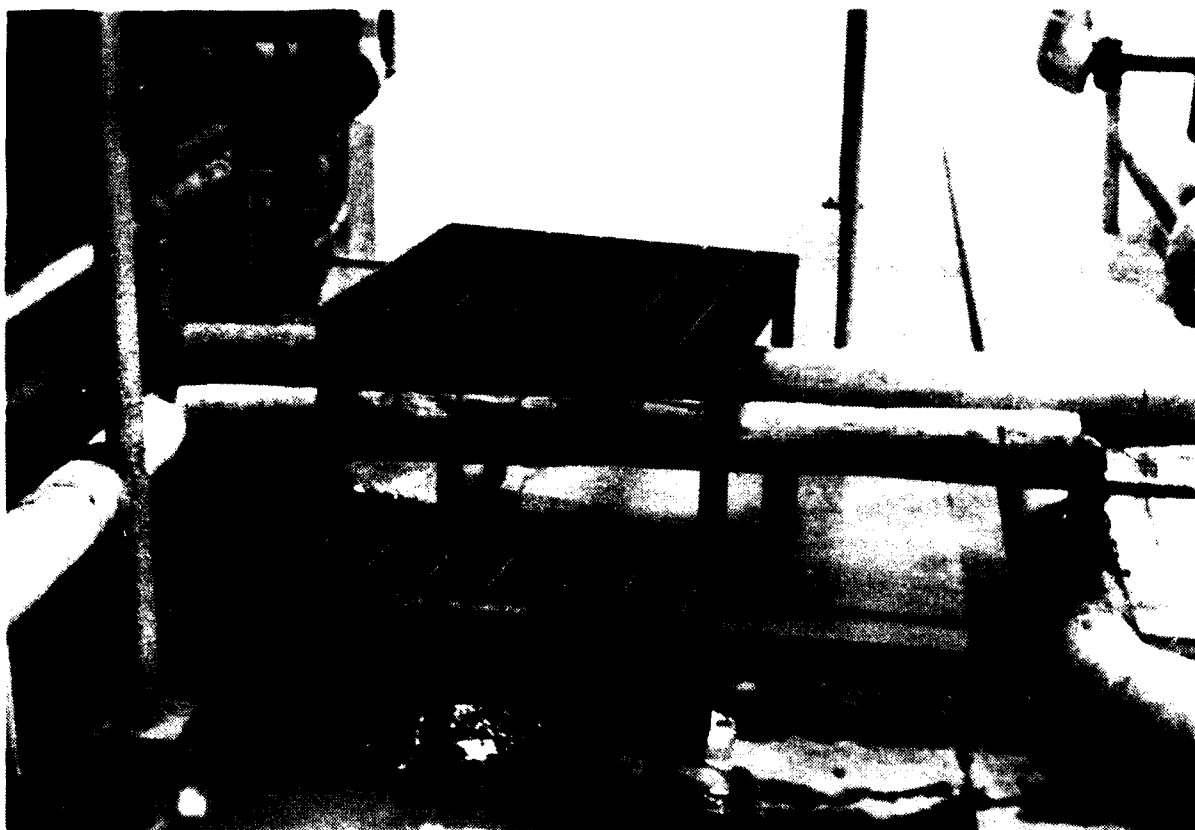


Figure A-3. Walkway between boiler and deaerator.

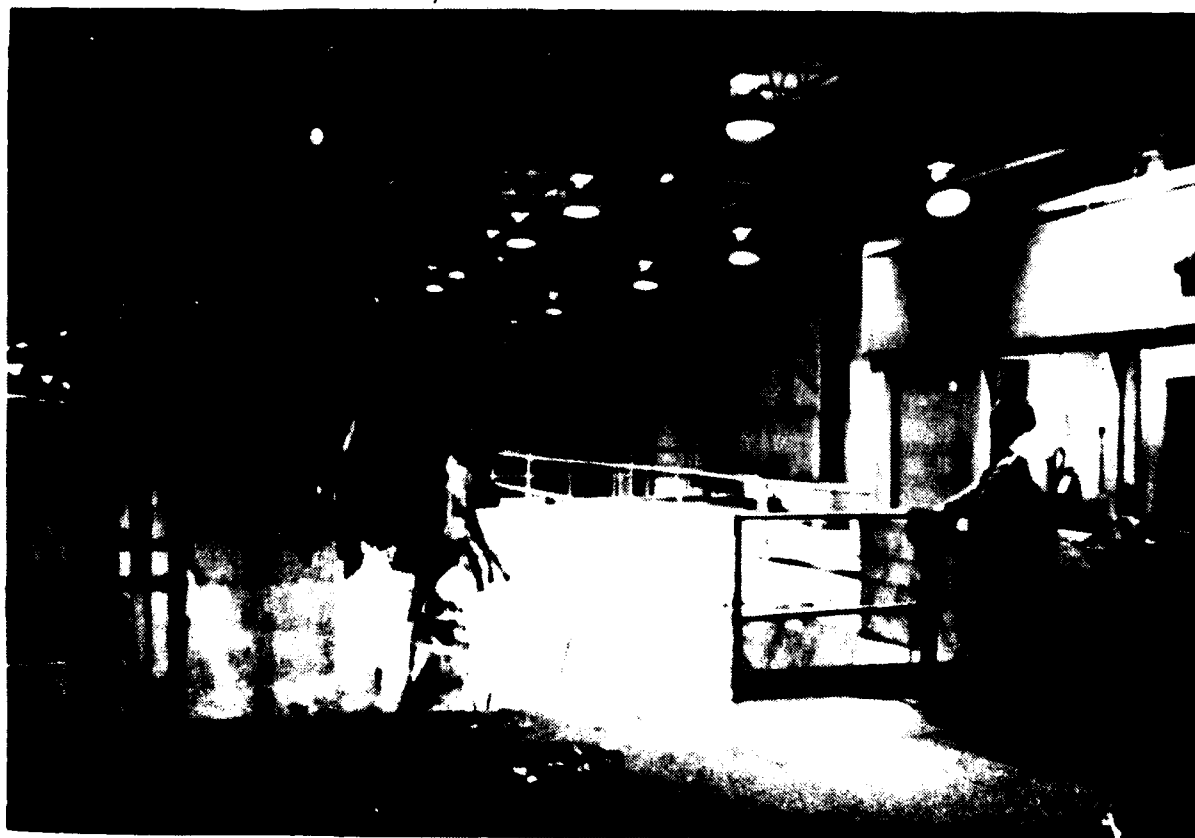


Figure A-4. Overhead crane operation.

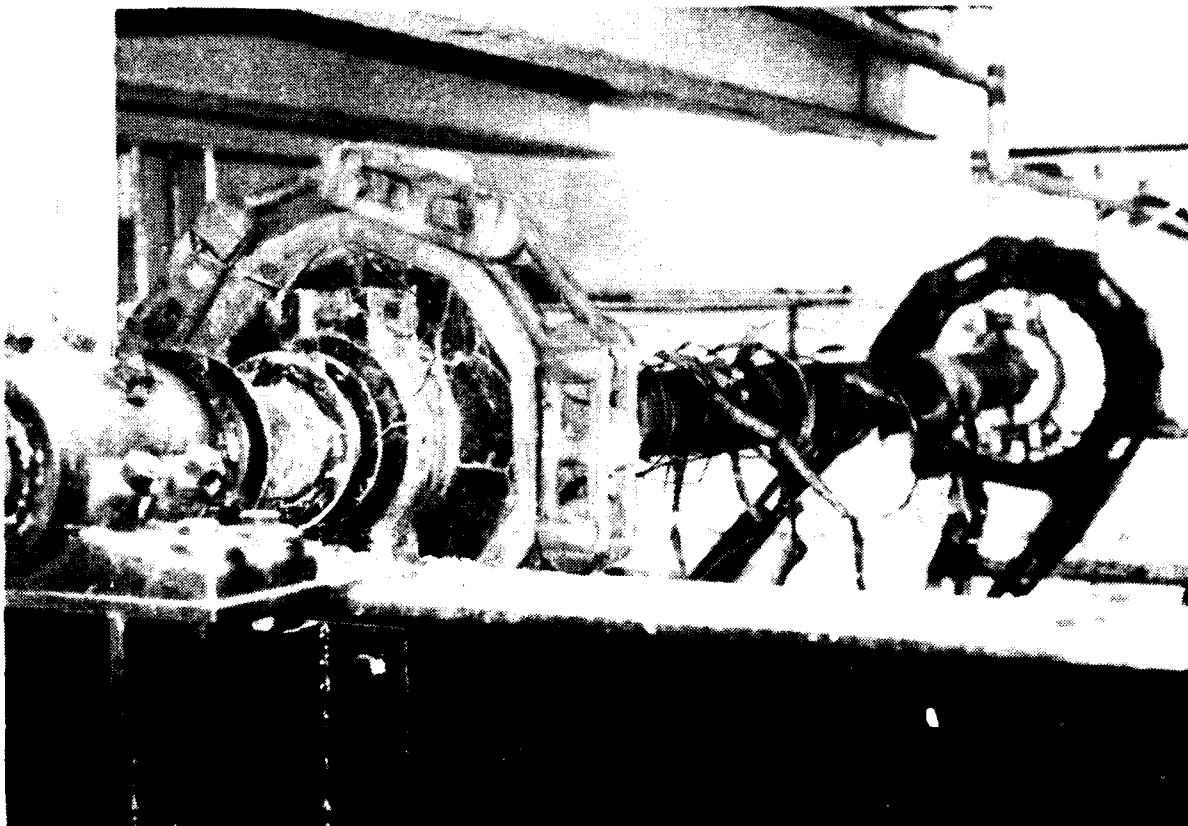


Figure A-5. Ash removal conveyor shaft and chain (discharge side).



Figure A-6. Boiler intermittent blowdown operation.

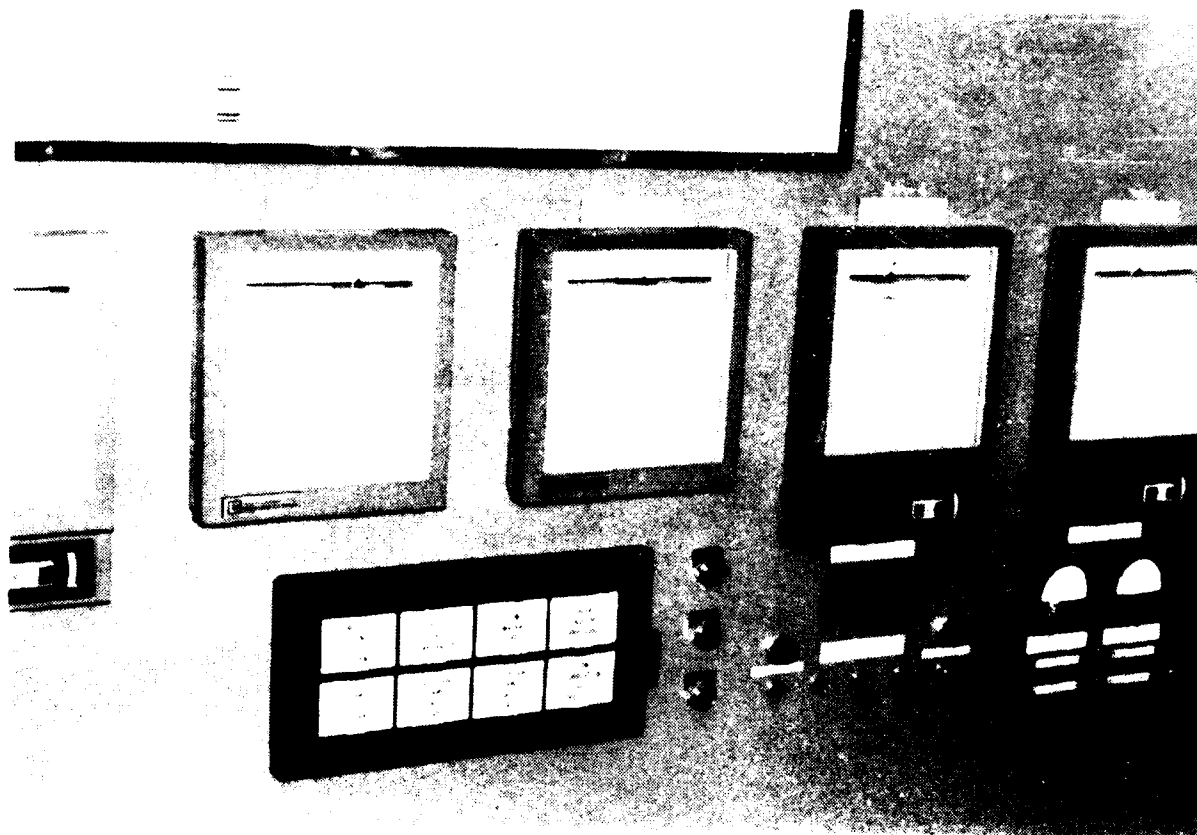


Figure A-7. Master control panel.

## NAS JACKSONVILLE

### 1. Tipping Floor Area

- Solid waste trucks required to back into facility (see Figure A-8) leading to "blindspot" hazards.
- Front-end loader tires not designed for cement tipping floor.
- Tipping floor size obviously too small to handle solid waste tipping, loader sorting, handsorting, and incinerator control (panels) operations (see Figures A-9 and A-10).
- Waste buildup (height) due to tipping floor congestion makes it difficult to efficiently sort out unburnables (see Figure A-10).
- Tipping and sorting operations not physically isolated from processing and incinerator feed operations.
- Handsorting requires frequent contact with toxics, glass, sharp and heavy objects.
- No apparent provisions for vermin control.
- Personal protective gear inadequate (gloves, clothing, etc.).

### 2. Processing Equipment

- Moving parts on conveyors and machinery exposed. Some only partially guarded (see Figures A-11 and A-12).
- Spillage from conveyors and processing machines is a problem. Especially near flail mill/vibrating conveyor and storage bin feed conveyor (see Figure A-13).
- Accessways, fixed ladders, and ramps should be provided for servicing, unjamming, and visual monitoring of equipment. Portable ladders disrupt traffic patterns and pose certain hazardous problems (see Figure A-14).
- Protective screens and other devices should be provided by original manufacturer and designed for anticipated load. Often the weight of the solid waste load exceeds that of the makeshift screens (especially when jams occur) which renders it ineffective (see Figure A-15).
- Location of motor control centers warrant local illumination. General facility lighting is insufficient due to shadows from processing equipment.
- Operation of processing train raises noise level within building above normal speech levels.

- Overhead conveyors unsafe for personnel below.
- Feeding of solid waste to flail mill pit must be performed by hand due to oversized bucket on front end loader.
- Often dangerous maintenance practices employed to resolve problems.

### 3. Boiler and Incinerator Equipment

- Incinerator control panels too close to hopper. Restricts direct feed capabilities.
- Portable fans with long extension cords used near incinerator control panels due to proximity of panels to hopper.
- Local incinerator control panels should be smaller with major controls being located in a master control room.
- Boilers, ID fans, and catwalks located outside, subjected to environmental/weather conditions. Electronmechanical equipment can pose serious shock hazards.
- Meters and valve controls on boilers require portable ladders (see Figure A-16) and long extensions to operate.

### 4. General

- Excessive dust levels inside building represents health concern and inhibits meter/indicator reading.
- Master control room should be location of primary operation control with visual view of entire processing and incineration operations. Local controls should have override capabilities.
- Lack of overall, enforced safety/health program.
- HRI layout should provide direct path from control room to incinerators and boilers. Use of step ladders and stairs should be avoided in such cases (see Figure A-17). For steep inclines (greater than 75 degrees) ladders are preferable to step ladders.

Figures A-8 through A-17 were taken at the NAS Jacksonville HRI facility.

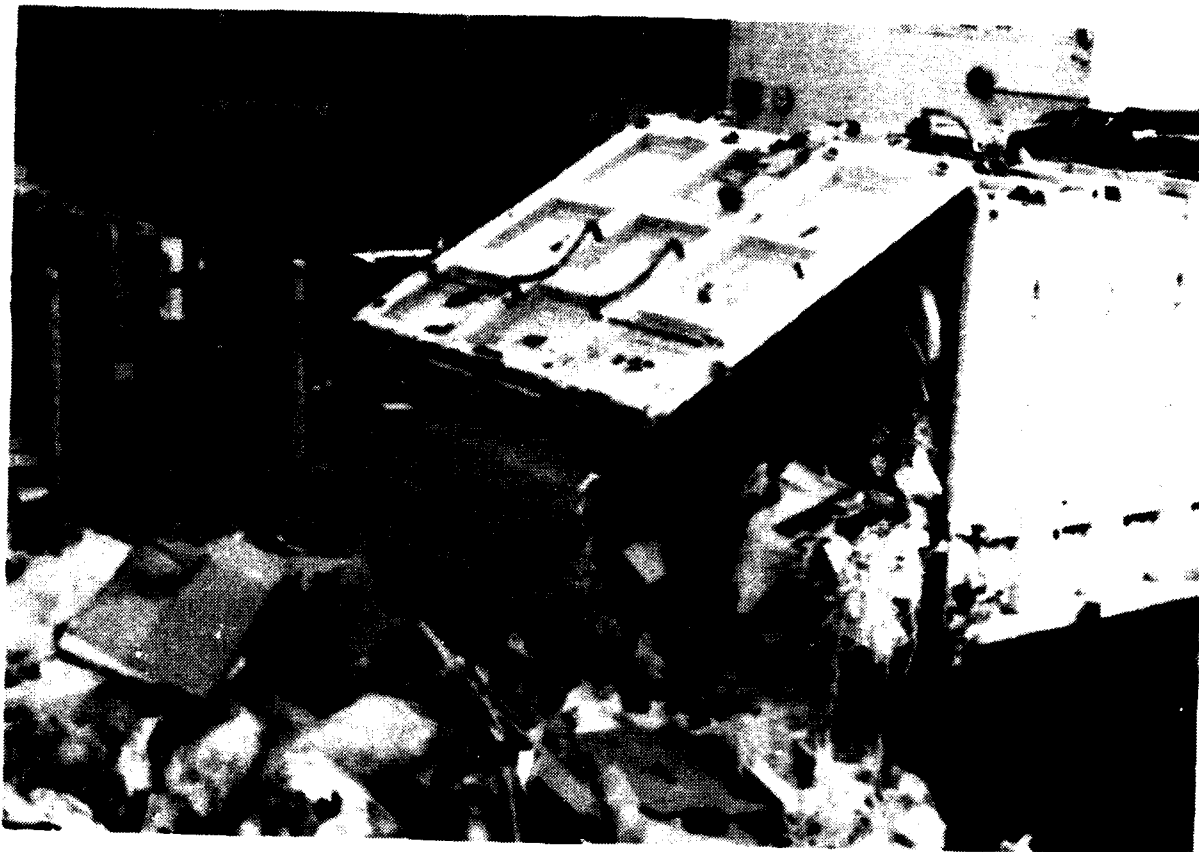


Figure A-8. Tipping floor, tipping operations.

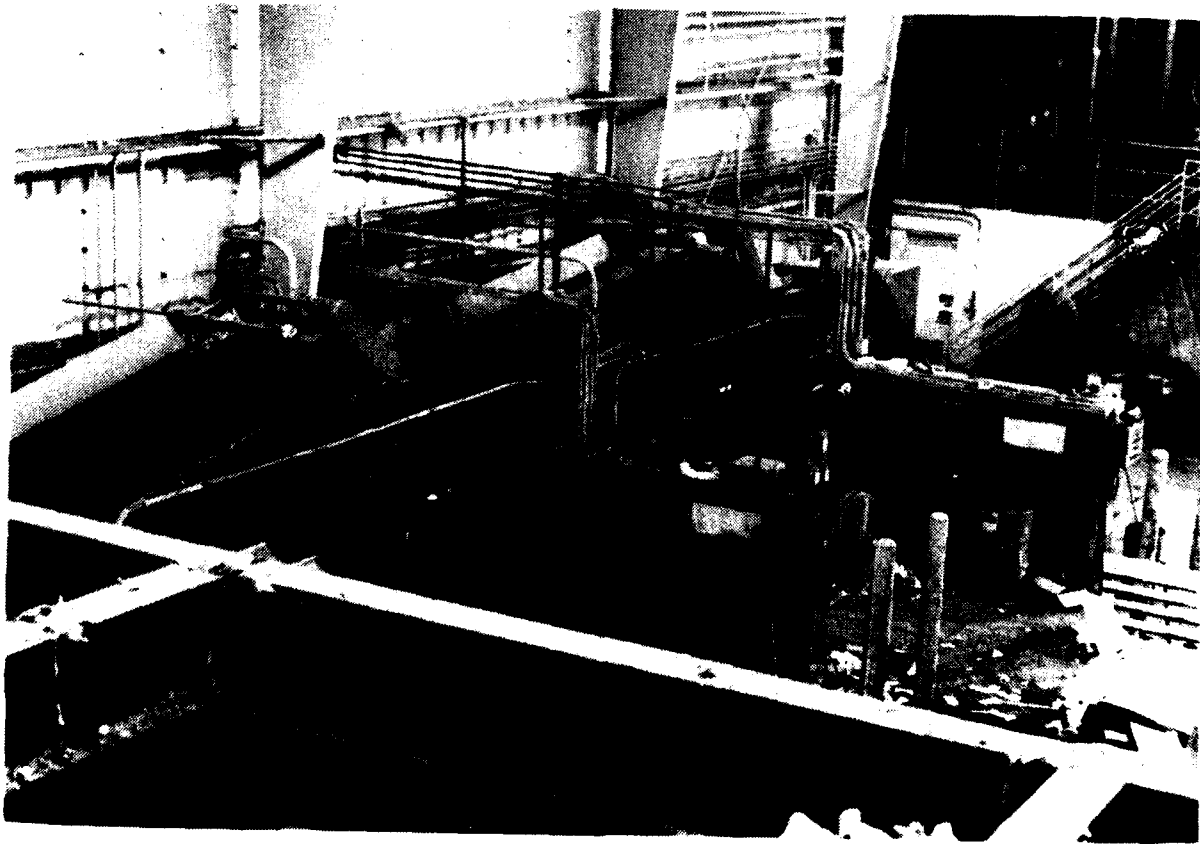


Figure A-9. Incinerator conveyors, panels, direct feed areas.



Figure A-10. Hand sorting on tipping floor.



Figure A-11. Shredder feed chain (discharge side).

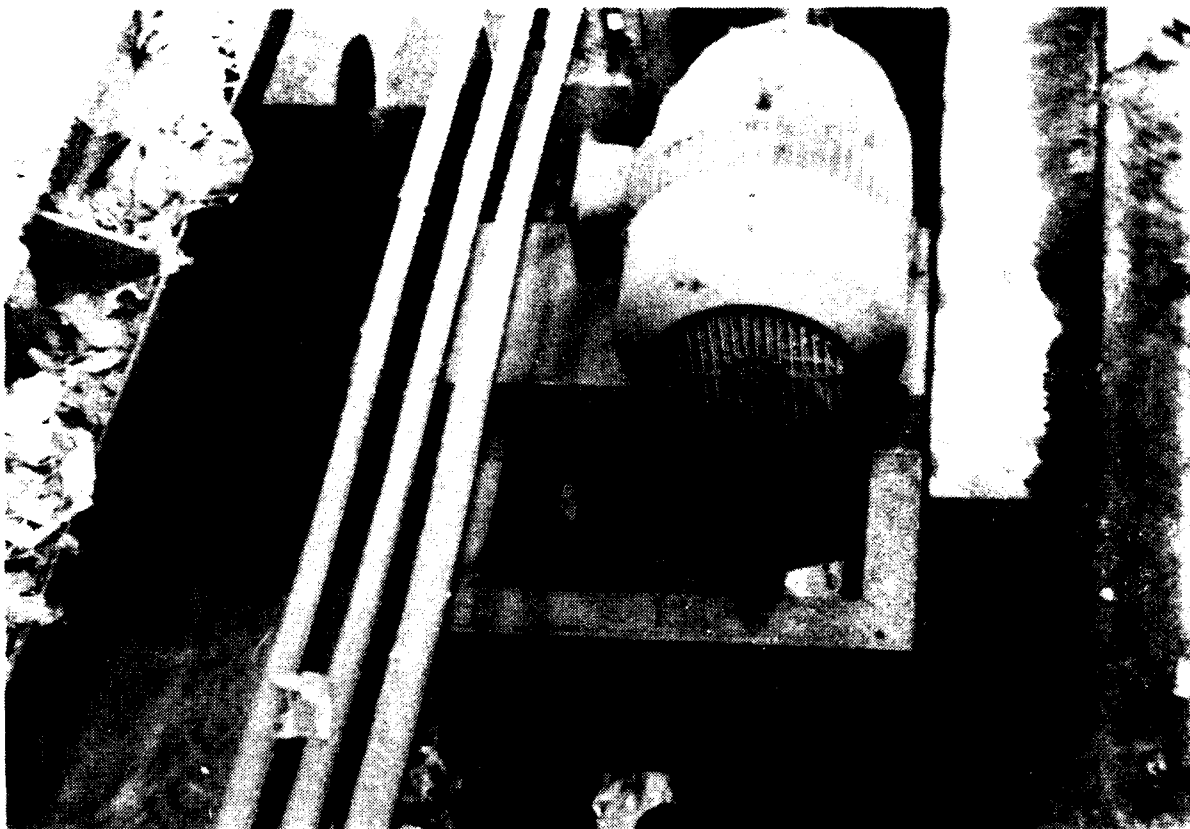


Figure A-12. Storage bin screw augers and drive carriage.

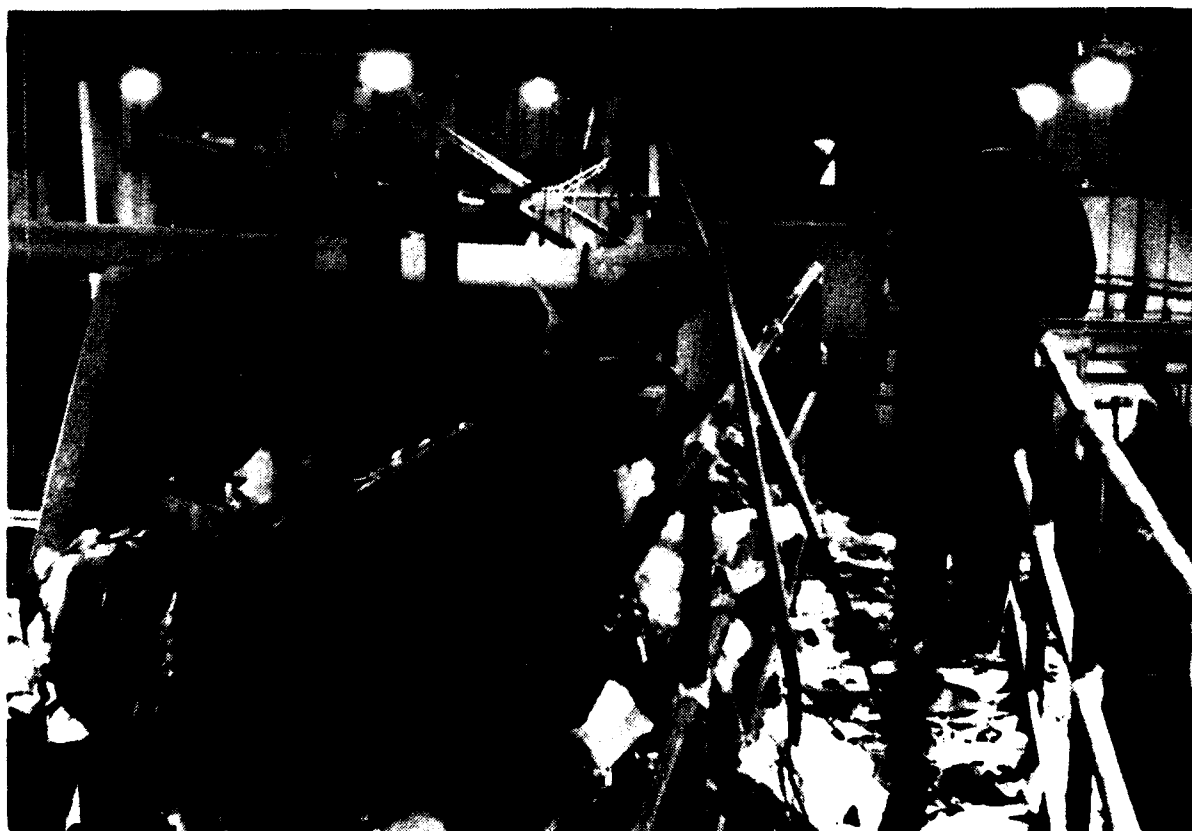


Figure A-13. Storage bin feed conveyor and catwalk.

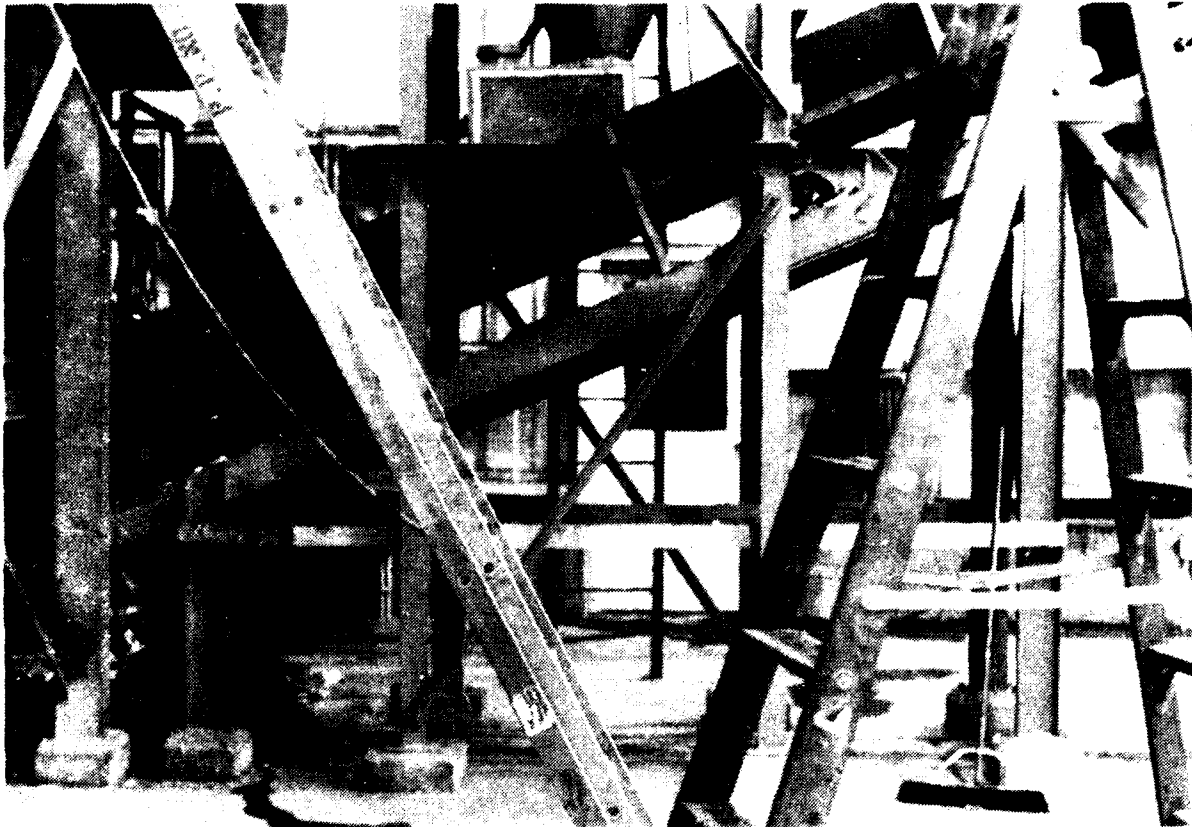


Figure A-14. Portable ladders in processing areas.



Figure A-15. Flail discharge conveyor, worn screen guard.



Figure A-16. Ladder for boiler instrument reading.

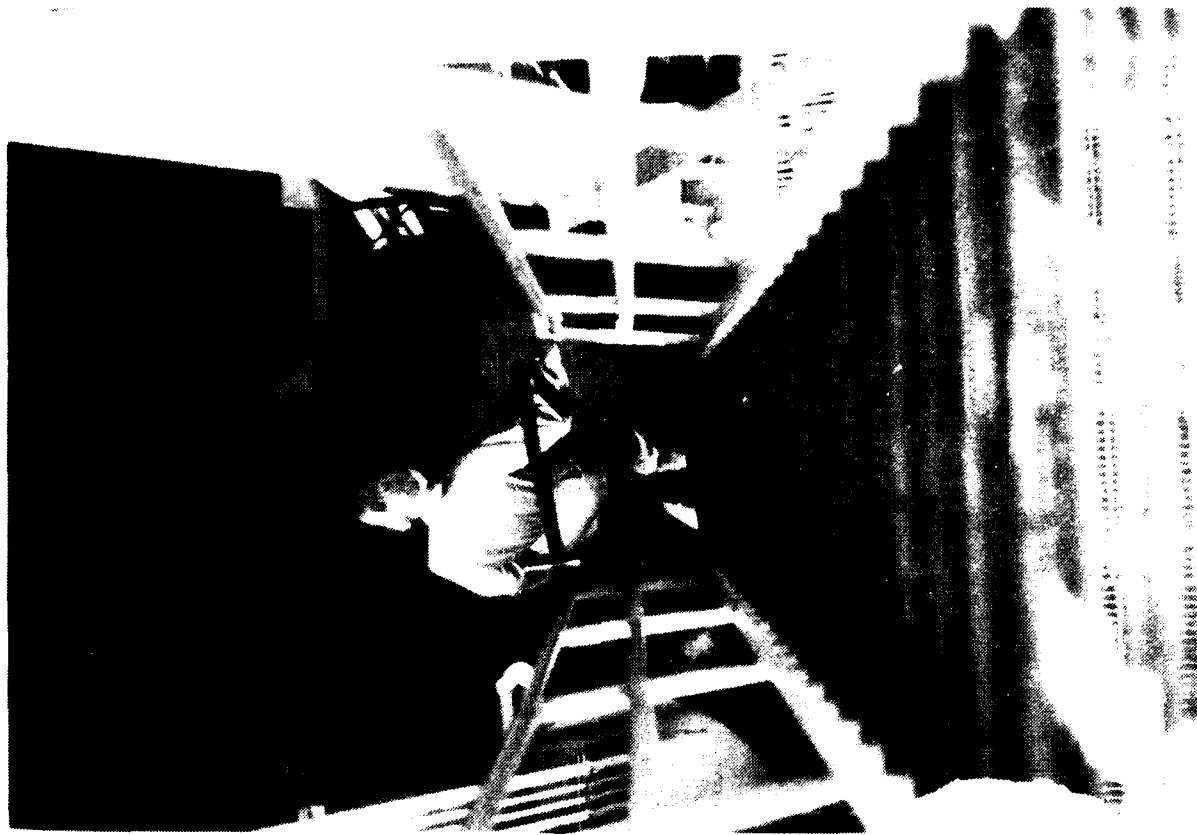


Figure A-17. Descending step ladder from boiler into plant.

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